MARAIS DES CYGNES BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody Assessment Unit: Big Sugar Creek
Water Quality Impairment: Dissolved Oxygen

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Lower Marais des Cygnes **Counties:** Anderson, Linn

HUC 8: 10290102 **HUC 11:** 10290102(070)

Drainage Area: 325 square miles

Main Stem Segments: WQLS: 31 and 32 (Big Sugar Creek) starting above the confluence with the Marais des Cygnes River traveling upstream to the headwaters of Big Sugar Creek in Anderson County.

Tributaries:
Little Sugar Creek (33)
- Little Sugar Cr N. Fork (43)
- Buck Cr (44)

Richland Cr (41)
Turkey Cr (45)
Davis Cr (38)
N. Sugar Cr (39)
Sugar Cr (42)

Designated Uses: For main stem segments: Expected Aquatic Life Support (32), Special Aquatic Life Support (31), Primary Contact Recreation C, Domestic Water Supply; Food Procurement; Ground Water Recharge; Industrial Water Supply Use; Irrigation Use; Livestock Watering Use.

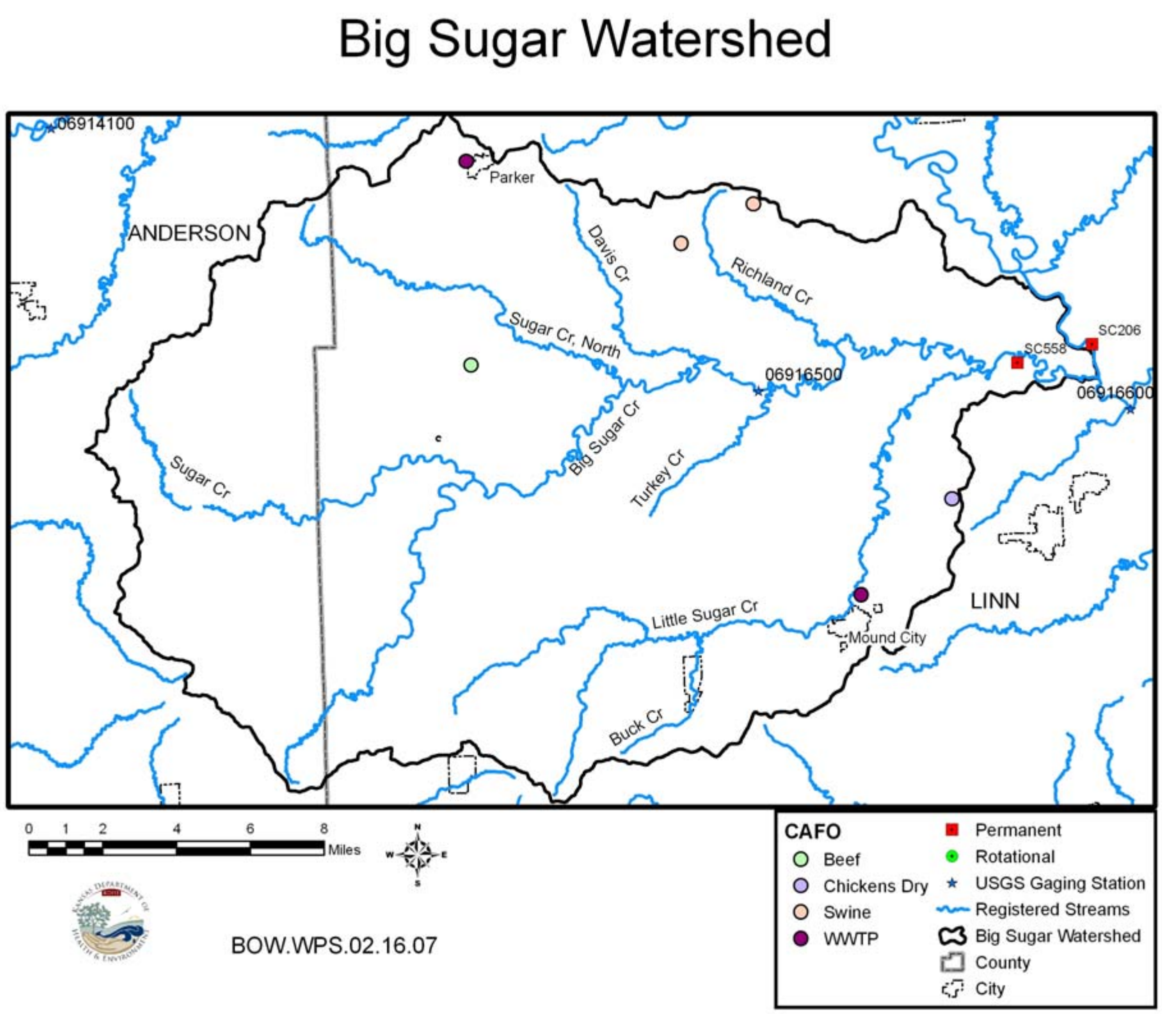
For tributary segments: Primary Contact Recreation B (33); PCR C (42, 39); Secondary Contact Recreation b (44, 38, 43, 41, 45); Special Aquatic Life Support (41); Expected Aquatic Life Support (44, 38, 33, 43, 42, 39, 45); Drinking Water Supply (39); Food Procurement (33, 42, 39); Ground Water Recharge (39), Industrial Water Supply Use (39); Irrigation Use (39); Livestock Watering Use (39).

2002, 2004, & 2006-303(d) Listing: Marais des Cygnes River Basin Streams

Impaired Use: Expected and Special Aquatic Life Support

Water Quality Standard: The concentration of Dissolved Oxygen in surface waters shall not be lowered by the influence of artificial sources of pollution. Dissolved Oxygen (DO): 5 mg/L (K.A.R. 28-16-28e(d), Table 1g).

Figure 1. Big Sugar Creek Watershed Basemap.



2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

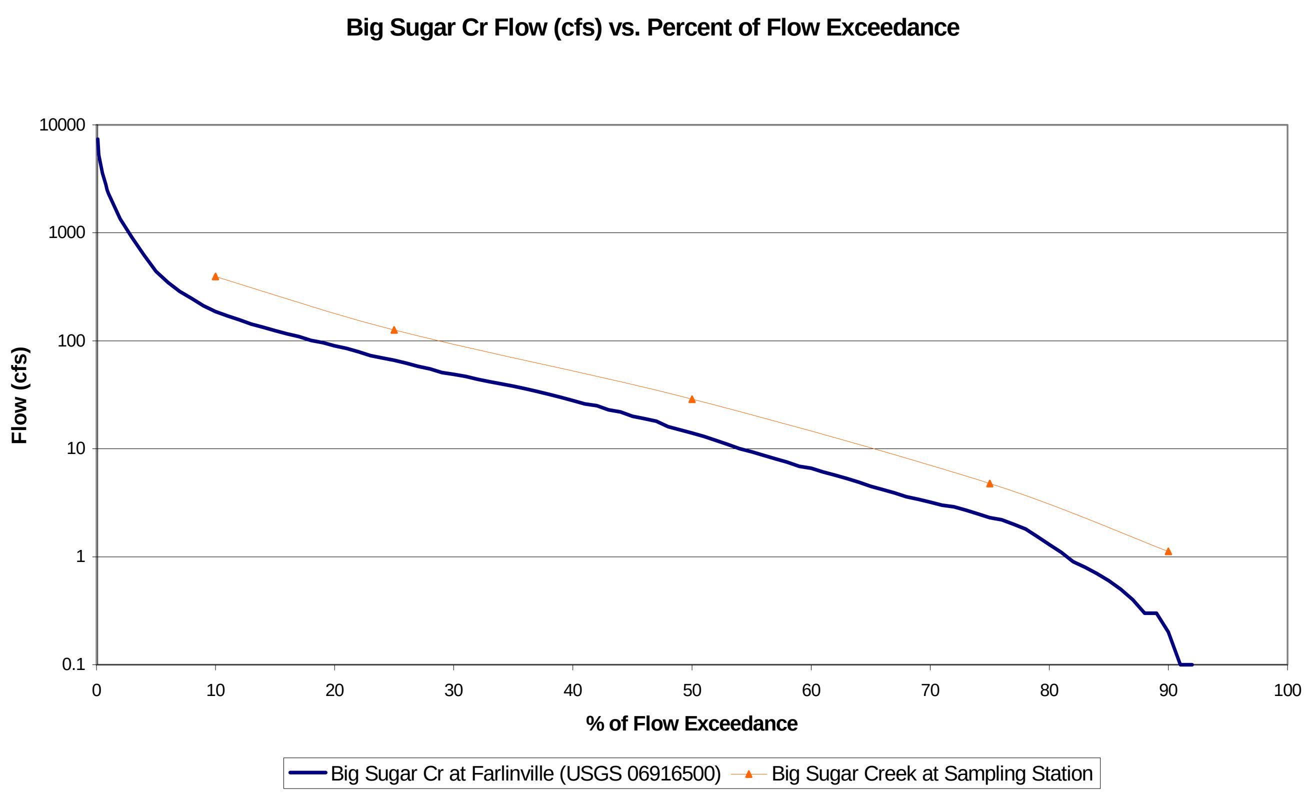
Level of Support for Designated Use under 2006-303(d): Not Supporting Aquatic Life

Monitoring Sites: Station 558 on Big Sugar Creek near Trading Post

Period of Record Used: 1990-2006 for Station 558

Flow Record: USGS Station 06916500 on Big Sugar Creek at Farlinville (1955-1970). A paired T-Test and Pearson Correlation test confirmed that older data from USGS Station 06916600 on the Marais des Cygnes River (downstream of the confluence of Big Sugar Cr) near the Kansas-Missouri State Line (1958-1970) was not significantly different from more recent data at the same station (1990-2006) and the data sets showed a significant correlation, which concludes that flow values along the Big Sugar Creek should not be significantly different and should correlate with the available historic flow record for the USGS Station 06916500 (See Appendix B).

Figure 2. Big Sugar Creek stream flow characteristics.



Long Term Flow Conditions:

Table 1. Long Term Flow Conditions in Cubic Feet per Second for Big Sugar Creek.

			Percent of time flow equaled or exceeded				
Location	Drainage Area	Mean Flow	90%	75%	50%	25%	10%
Big Sugar Cr at Farlinville (USGS 06916500)	181 mi^2	129	0.2	2.3	14	66	187.2
Big Sugar Cr near Trading Post (Sampling Station 558)	325 mi^2	246	1.12	4.76	28.8	126	394

Current Condition: Since loading capacity varies as a function of the flow present in the stream, this TMDL represents a continuum of desired concentrations over all flow conditions, rather than fixed at a single value. Sampling data from station 558 was categorized into three defined seasons: Spring (April- June), Summer-Fall (July-October), and Winter (November-March). High flows and runoff equate to lower flow durations; baseflow and point source influences generally occur in the 75-99% range. The median flow is the 50% flow exceedance value.

Seasonal and monthly dissolved oxygen (DO) concentrations are displayed in **Figures 2 and 3**. Average concentrations are the lowest during the months of the Summer-Fall Season along with the month of November during the Winter Season.

Figure 2. Average Monthly DO Concentrations for Big Sugar Cr.

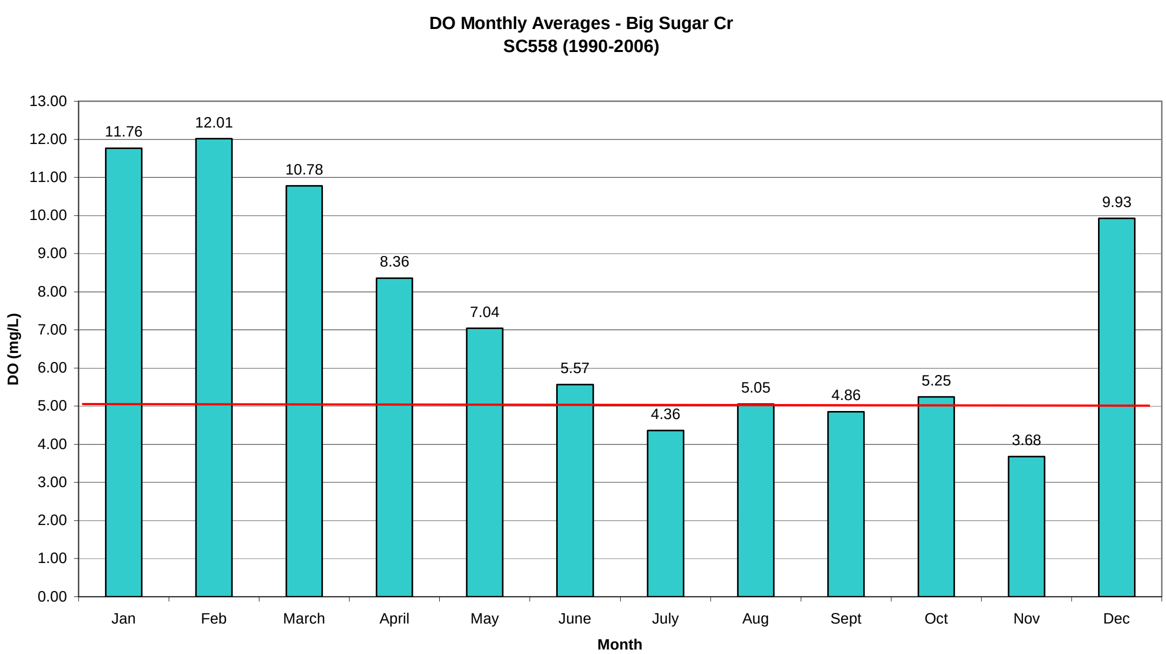
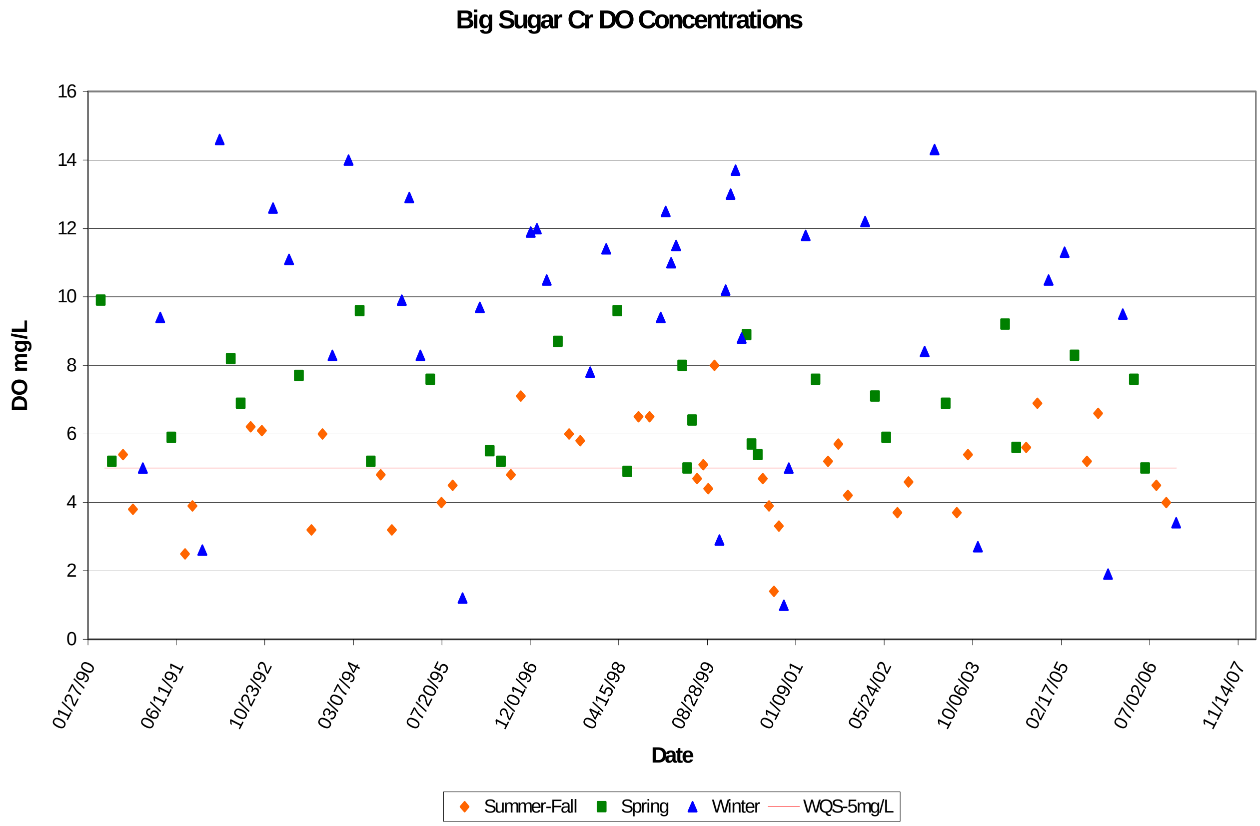


Figure 3. Seasonal DO Concentrations in Big Sugar Cr.



As observed in **Table 2 and Figure 4**, the majority of the DO violations (< 5 mg/L) were observed during the Summer-Fall season, especially during flows less than the median flow (50-100% flow exceedance). The samples collected during the Spring Season were collected at times with greater flows, which coincide with spring rainfall and runoff. The one violation during the Spring Season was obtained when the flow was less than the median flow. The Winter Season contains several violations at flows less than the median flow and there were no violations at flows higher than the median flow.

Historic monthly streamflows along Big Sugar Creek are illustrated in **Figure 5**. Months with the lowest flows occur during the Summer-Fall season and correspond well with lower average monthly DO concentrations observed in the stream during the months with lower flows (**Figure 2**). Within Big Sugar Creek, the Summer-Fall Season has the lowest average monthly flows, the lowest average DO concentrations, and the majority of the observed DO violations.

Table 2. Number of DO Violations <5mg/L by Season and % of Flow exceedance.

Station	Season	0 -10%	10-25%	25-50%	50-75%	75-90%	90-100%	Cum. Freq.
Big Sugar Cr (558)	Spring	0/5	0/4	0/12	1/7	0/0	0/1	1/29=3%
	Summer-Fall	2/3	0/2	2/8	5/11	8/11	4/4	21/39=54%
	Winter	0/2	0/8	0/9	2/8	1/4	4/8	7/39=18%

Figure 4. DO Concentrations by season vs. Percent of Flow Exceedance.

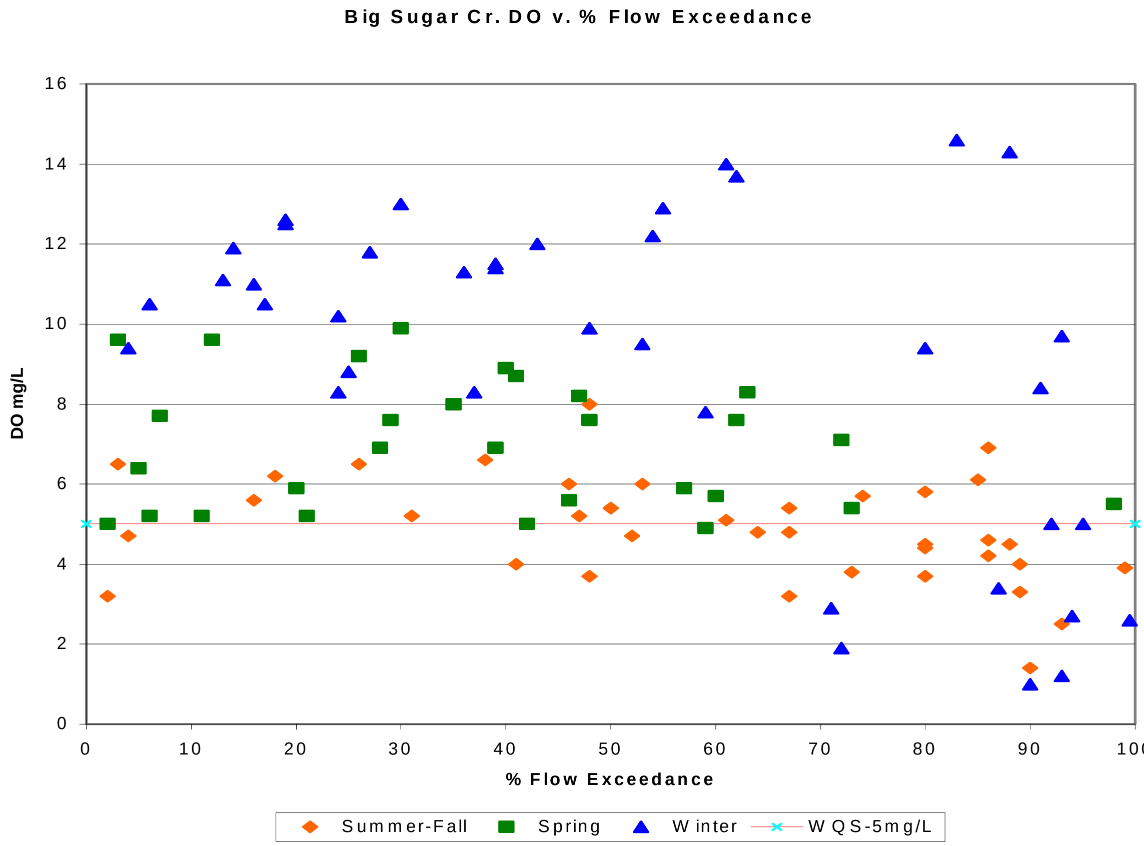
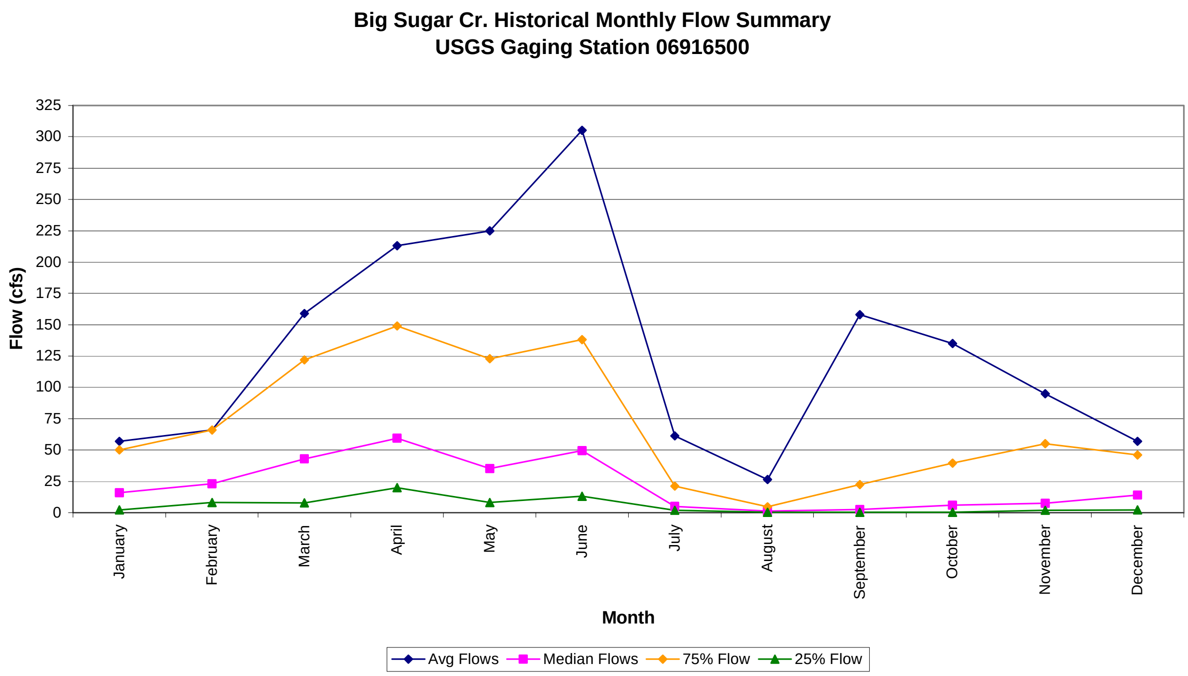


Figure 5. Historical average monthly flow summary for Big Sugar Creek at Farlinville.



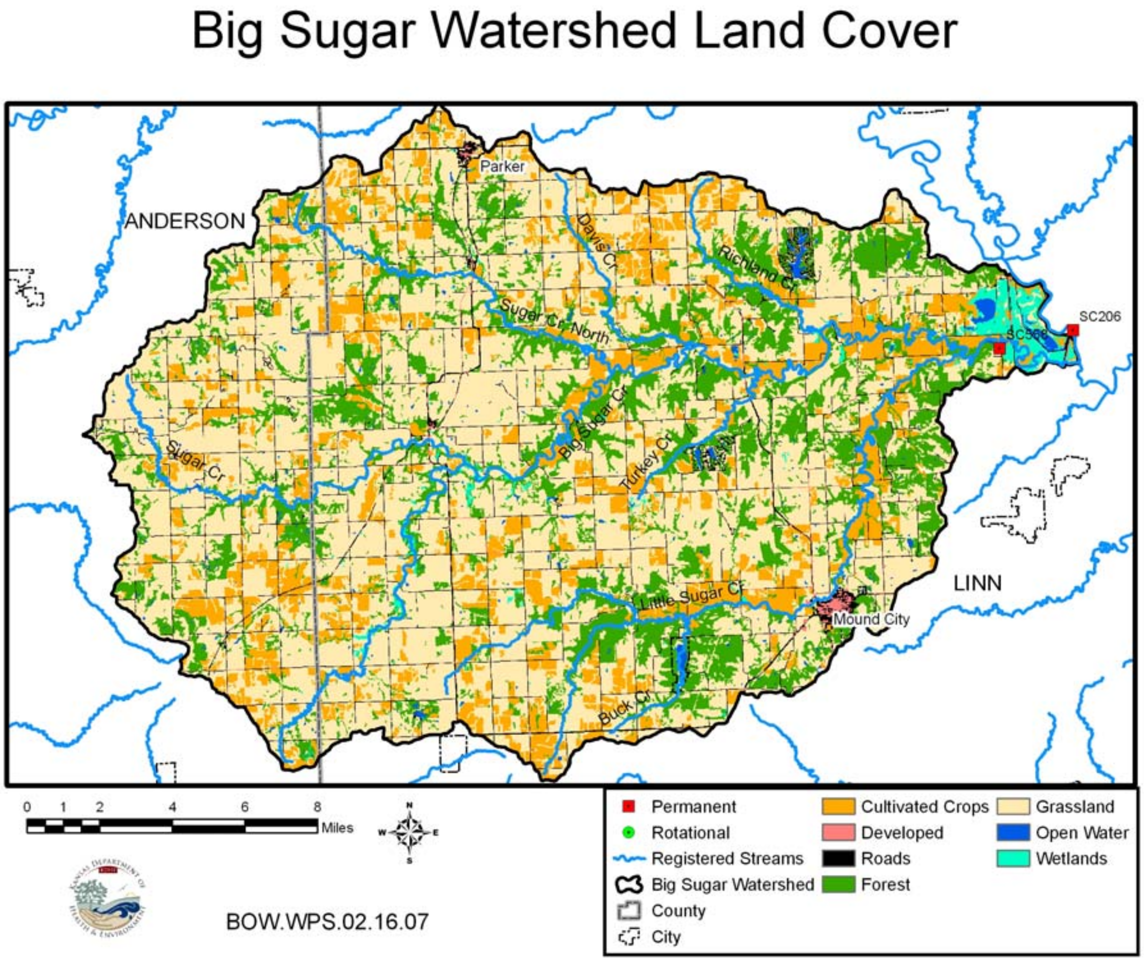
Desired Endpoints of Water Quality (Implied Load Capacity) for Big Sugar Creek at Site 558:

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Aquatic Life, indicated by dissolved oxygen concentrations of 5 mg/L or more. Seasonal variation is accounted for by this TMDL, since the TMDL endpoint is sensitive to the low flow and temperature conditions usually occurring in the Summer-Fall Season and higher DO levels occur during the spring when flows are typically the highest. Achievement of the endpoint indicates any loads of oxygen-demanding substance are within the loading capacity of the stream, water quality standards are attained and full support of the designated uses of the stream has been restored.

3. SOURCE INVENTORY AND ASSESSMENT

Land Use: As displayed in Figure 6, the predominant land use within the Big Sugar Creek watershed is cultivated cropland and grasslands, which account for 43% and 37% of the total land area in the watershed respectively. The urban areas primarily associated with the City of Parker and Mound City, only account for 1% of the watershed. Approximately 9% of the land is occupied by pasture or hay and about 4% is deciduous forest.

Figure 6. Big Sugar Creek Land Cover Map.



NPDES: There are two NPDES permitted dischargers within the watershed (**Table 3**). The dischargers are municipal wastewater treatment facilities associated with Mound City and the City of Parker. Both cities have permit limits for BOD in their effluent, which are weekly averages of 45 mg/L and monthly averages of 30 mg/L over 2004-2009.

The City of Parker averaged 26.7 mg/L of BOD in their effluent from 2003-2006, and probably does not contribute enough flow to deliver loads down to the KDHE monitoring site.

Mound City is much closer to the sampling station and therefore may contribute to the DO impairment observed at station 558. The facility at Mound City was recently upgraded in April of 2005. The upgrades included adding a third lagoon and expanding capacity to their existing facility. The surface area of the old two-cell lagoon system was

4.42 acres and was designed to discharge 0.048 MGD. The new three-cell stabilization lagoon has a surface area of 10.35 acres and a design flow of 0.13 MGD. The BOD concentrations in the Mound City effluent averaged 45.9 mg/L for four sampling events from May of 2004 to March of 2005, which was prior to the completion of the plant upgrade. Once the third cell came online, the facility did not discharge for several months as the lagoon filled up. After the third lagoon was activated and full, there appears to be a lag time of about one year when the "bugs" began to flourish and efficiently reduce the effluent BOD concentrations. The BOD concentrations in the Mound City effluent averaged 35 mg/L for the first year after the upgrades were complete, which encompassed three sampling events from September of 2005 to March of 2006. The most recent three quarters of effluent sampling, from June to December of 2006, indicates that the upgraded facility is working much more efficiently as the recent BOD effluent concentrations average 16 mg/L.

Table 3. Discharging Wastewater Systems in the Big Sugar Creek Watershed.

KS Permit #	Fed Permit #	Facility	Type	Permitted Flow (MGD)	Recv Stream	Permit Expires
M-MC26-OO01	KS0047503	Mound City WWTF	Lagoon	0.13	Little Sugar Cr	6/30/09
M-MC34-OO01	KS0080152	City of Parker WWTF	Lagoon	0.0463	North Fork Sugar Cr via 2 Tribs	9/30/09

Livestock Waste Management: There are four active confined animal feeding operations (CAFOs) within the Big Sugar Creek Watershed, of which three are permitted and one is certified. These facilities are not likely to contribute any pollutant causing the impairment because they are designed not to discharge and the stream system is dewatered sufficiently when the majority of the DO violations occurred that it is likely that if a spill were to occur it probably would infiltrate into the immediate stream channel and not flow down into the main segment of Big Sugar Creek. Furthermore, any spill will be associated with wet weather and high flows, conditions that do not have many DO violations. In addition, none of the CAFOs are within the 30-meter buffer area along the streams within this watershed (Figure 1).

Table 4. Characteristics of four animal feedlot operations in the Big Sugar Cr. Watershed.

Permit #	Type	Animal Units
A-MCLN-BA01	Beef - Certified	250
A-MCLN-S018	Swine - Permitted	740
A-MCLN-S005	Swine - Permitted	450
A-MCLN-F001	Chickens Dry - Permitted	30,500

Population Density: Population estimates developed by the Kansas Water Office for both Mound City and the City of Parker indicate a slight increase projected through 2030. The total population in the watershed according to the 2000 census data from the U.S. Census Bureau is 3,603, of which 1,102 people live within the city limits of Mound City and the City of Parker. The watershed population density is 11-people/ square mile.

On-Site Waste Systems: Based on the 1990 census data, about 46% of the households in Linn County utilize septic systems. The households within the watershed that are not served by the sewer systems of the City of Parker or Mound City are presumably on septic systems. Based on the 2000 census data, approximately 70% of the residents within the watershed are served by septic systems. Though they are not likely to contribute to the DO impairment in Big Sugar Creek, failing on-site septic systems can contribute significant nutrients loadings within the watershed.

Contributing Runoff: The Big Sugar Creek watershed's average soil permeability is 0.63 inches/hour according to the NRCS STATSGO database, ranging from 0.01 inches/hr to 4.0 inches/hr. About 75% of the watershed produces runoff under low runoff conditions. Runoff is primarily generated as infiltration excess with rainfall intensities greater than soil permeability. As the watersheds' soil profiles become saturated, excess overland flow is produced.

Correlation of DO with other Parameters: Results of the water quality analyses indicates that stream flow, temperature, and BOD concentrations influence DO excursions. Elevated BOD concentrations (>3.5 mg/L) tend to influence the DO concentrations in the Summer-Fall and Winter Seasons. As seen in Figure 7, the DO violations that occur with higher BOD concentrations are influenced by BOD loadings. The DO violations that occur with lower BOD concentrations, < 3.5 mg/L, are a result of natural conditions associated with low flow and higher temperatures.

Figure 7. DO and BOD concentrations for samples obtained on Big Sugar Cr. (558).

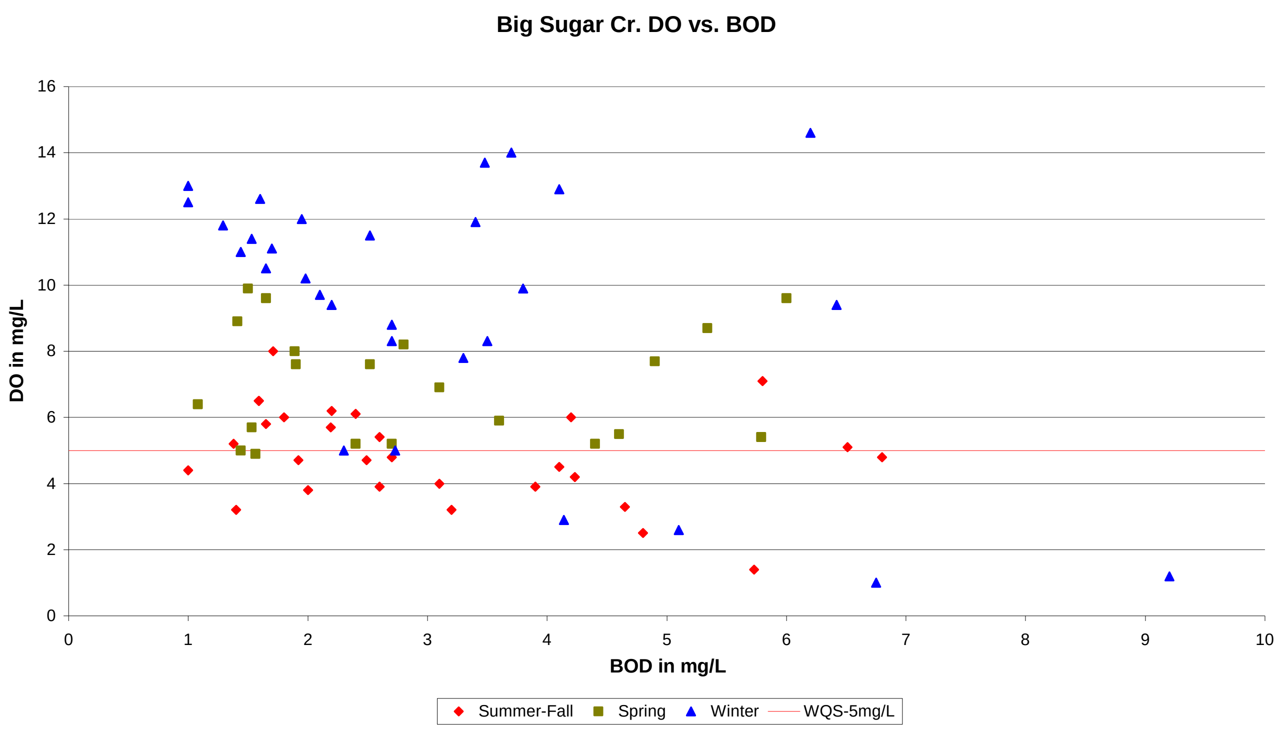


Figure 8. BOD concentrations at Station 558 relative to flow duration and season.

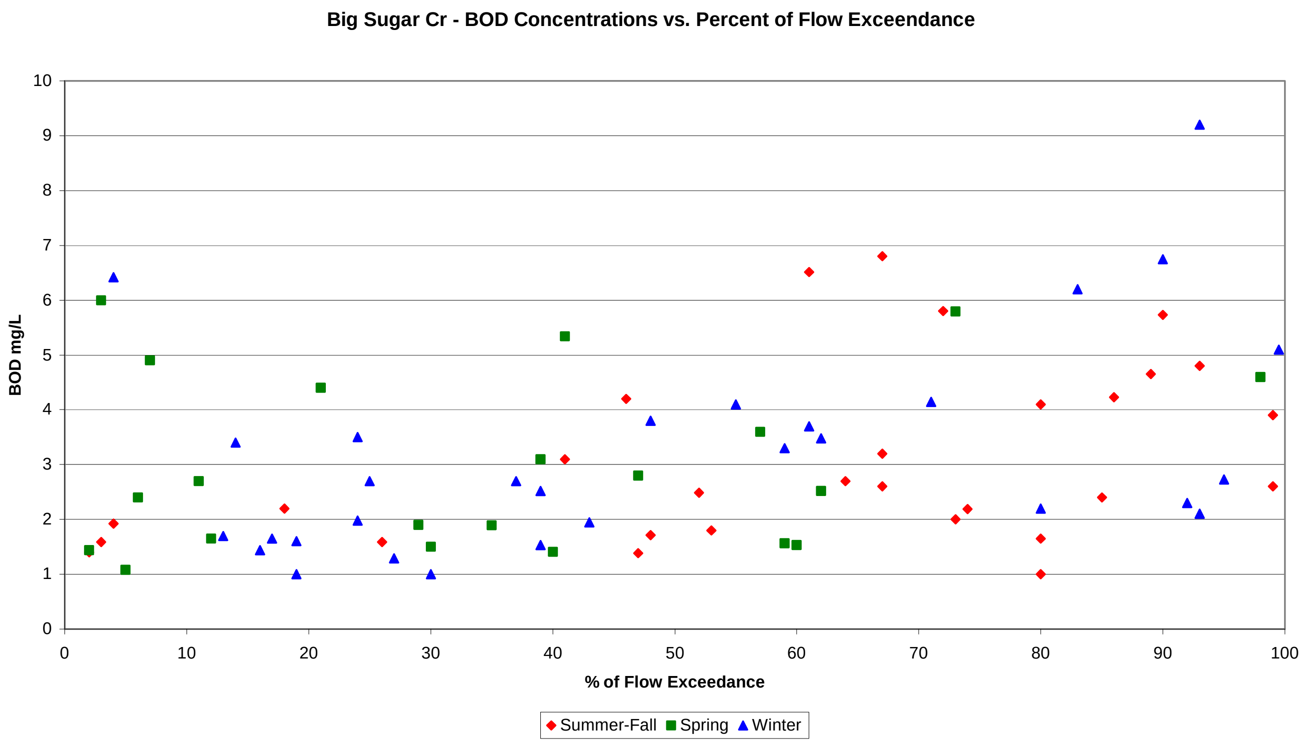


Figure 9. BOD concentrations at 558 relative to flow duration and DO concentration.

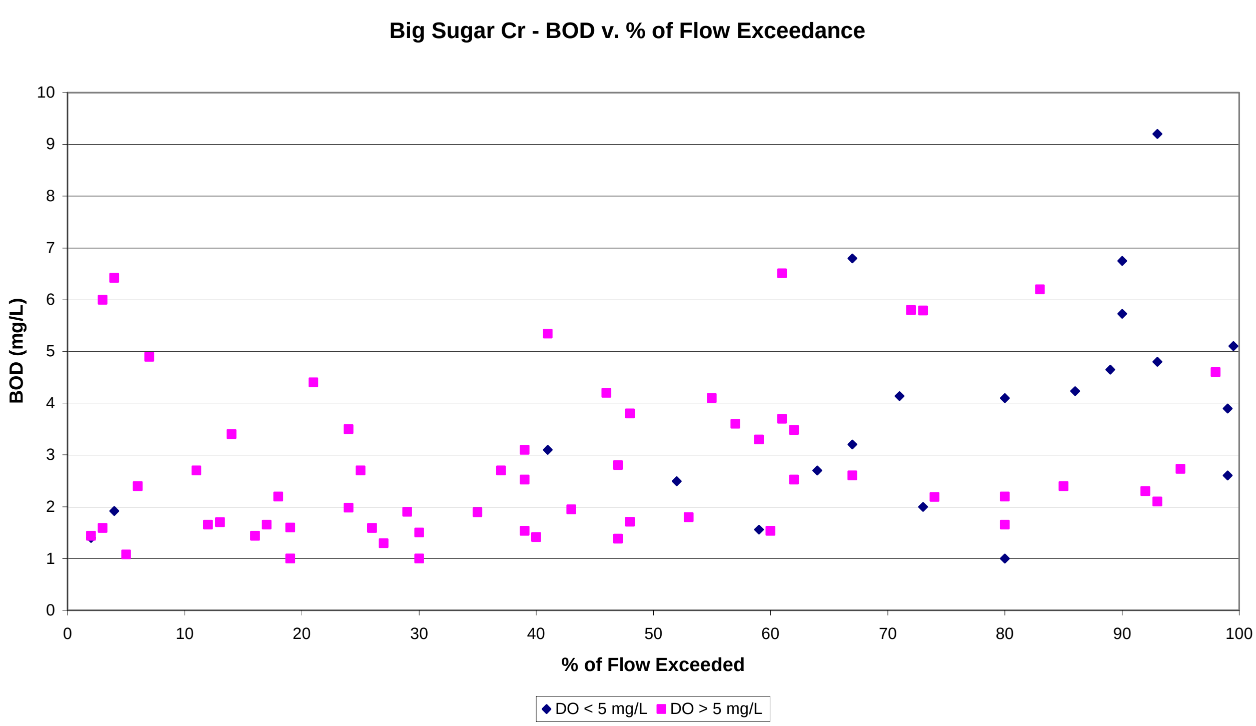


Figure 10. DO and TOC concentrations for samples obtained on Big Sugar Cr. (558).

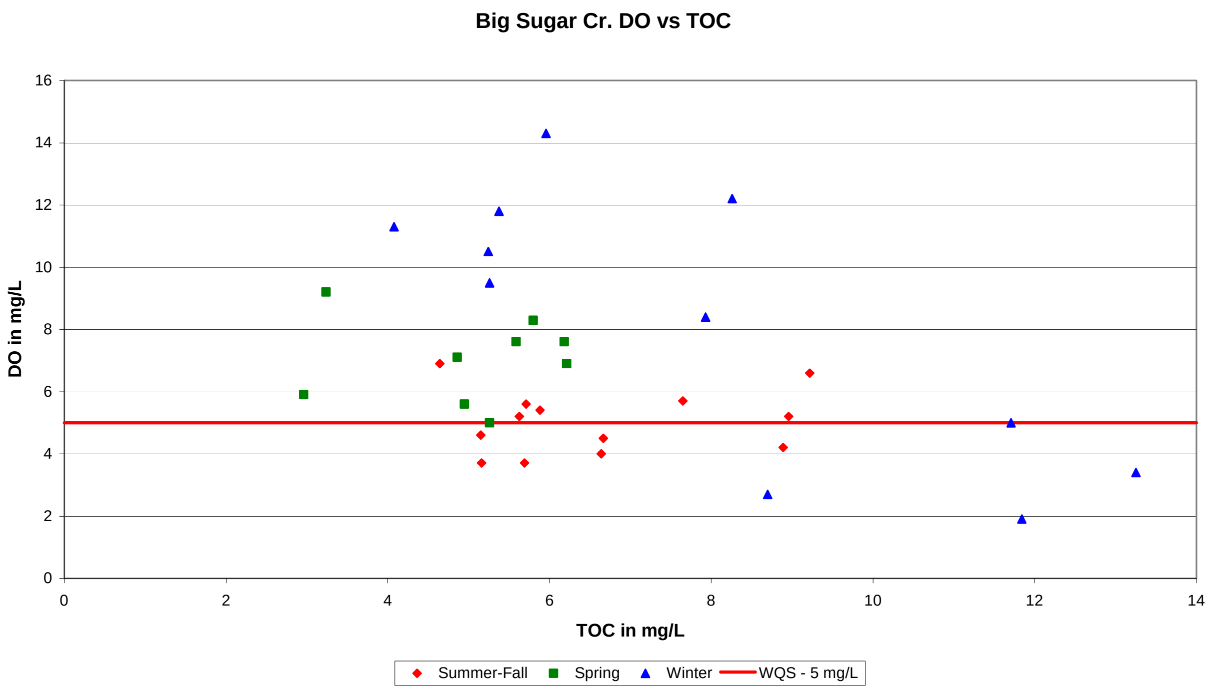


Figure 11. TOC concentrations at Station 558 relative to flow duration and season.

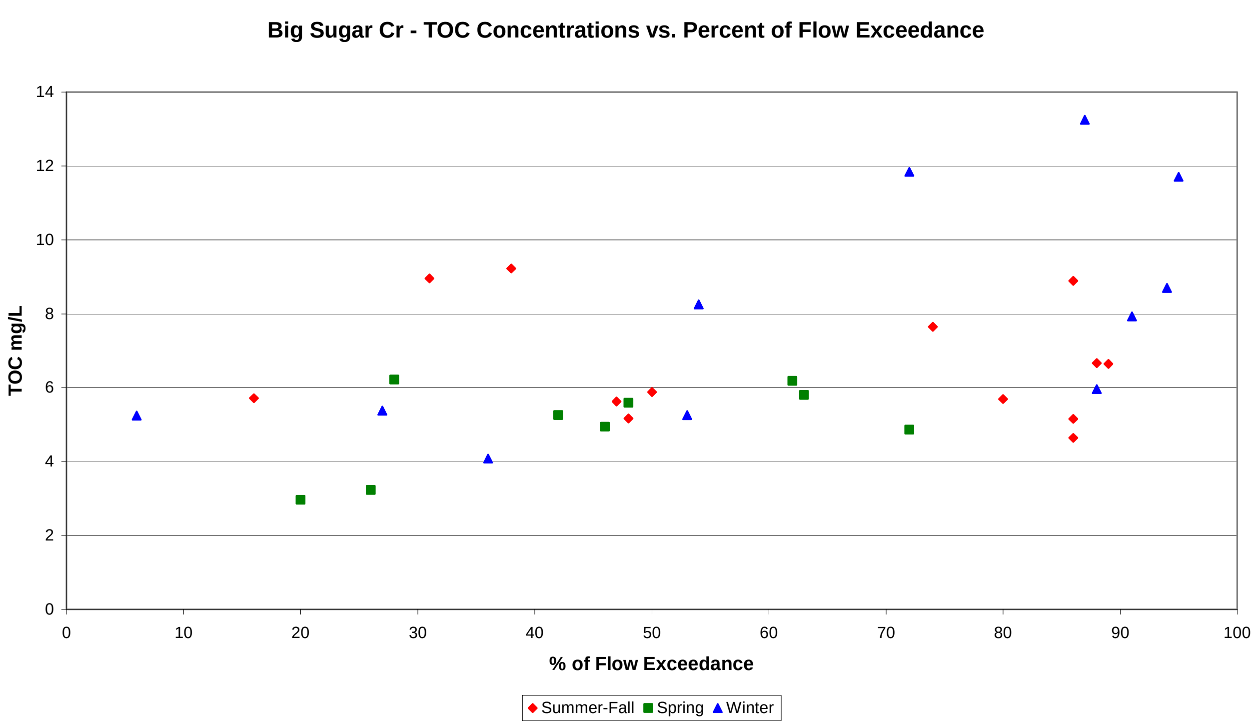
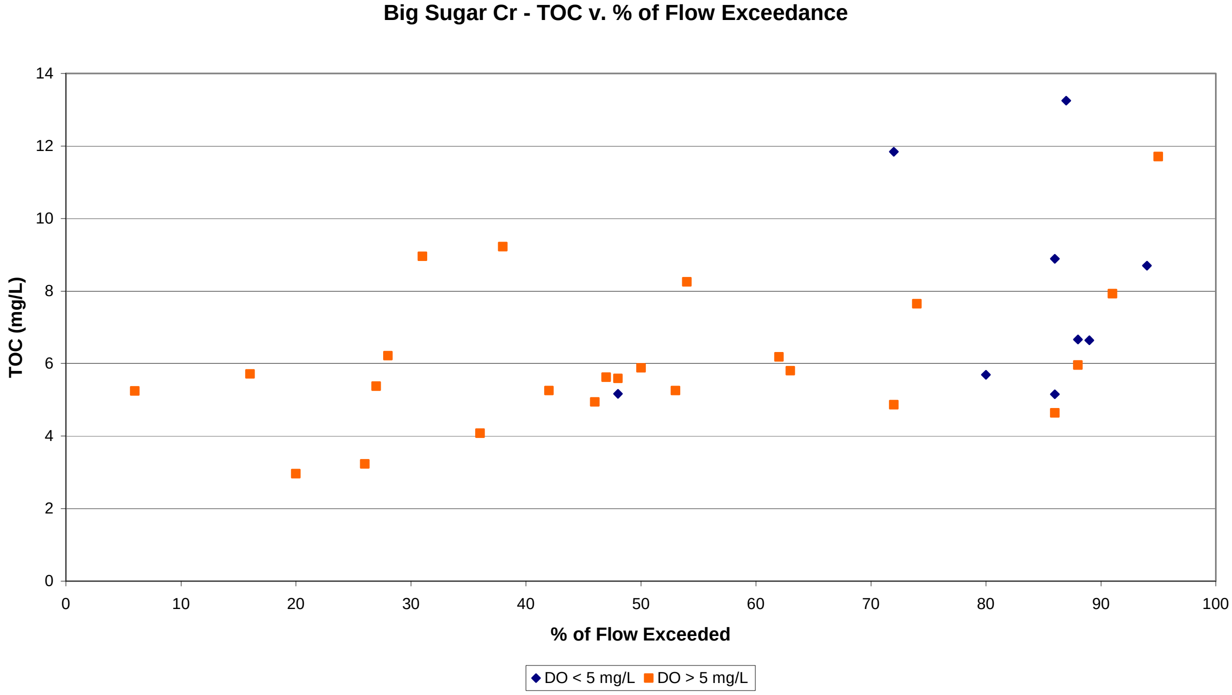


Figure 12. TOC concentrations at 558 relative to flow duration and DO concentration.



There are 25 samples that have elevated BOD concentrations over the three defined seasons that are greater than 3.5mg/L. There were no DO impairments under higher flow conditions when the BOD levels were elevated. During the Summer-Fall and Winter Seasons, 33% of the elevated BOD samples had DO violations during the base flow condition (50-75% flow duration) and 90% of the elevated BOD samples had DO violations during low flow conditions (75-90% flow duration).

Table 5. Summary of samples at station 558 with elevated BOD concentrations.

Station 558	Season	0-25%	25-50%	50-75%	75-100%	Cum. Freq.
Samples with Elevated BOD (>3.5mg/L)	Spring	3/8	1/7	2/5	0/1	6/21= 29%
	Summer-Fall	0/4	1/5	3/10	6/10	10/29=35%
	Winter	1/9	1/8	3/5	4/8	9/30=30%
Samples with Elevated BOD & DO Impairment	Spring	0/3	0/1	0/2	0/0	0/6=0%
	Summer-Fall	0/0	0/1	1/3	6/6	7/10=70%
	Winter	0/1	0/1	1/3	3/4	4/9=44%

KDHE discontinued sampling for BOD in 2001 and began utilizing Total Organic Carbon (TOC) analyses in late 2000 in lieu of BOD. KDHE conducted analyses in 2000 to determine if TOC concentrations could be utilized as a surrogate for BOD and whether a statistical translation could be made for this expression. KDHE utilized 675-paired sets of data in the analyses and concluded that there are relationships in the stream data. “The data suggest that, for effluent and point source related waters, the BOD/TOC ratio is almost one-to-one. Ambient waters have much lower ratios, suggesting that a portion of the TOC is in more refractory substances (i.e., cell walls, lignin, cellulose, etc.)” (Carney, 2000). The analysis of the paired ambient stream data was utilized for this report. The regression analyses for this group is summarized as follows:

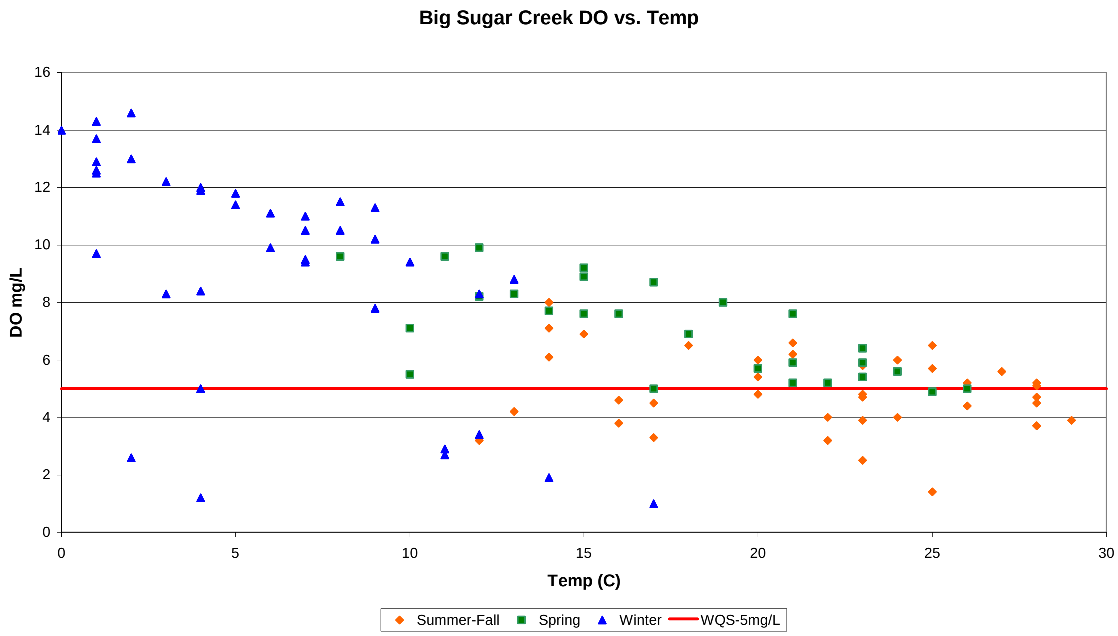
R square = 0.34
P Value = < 0.0001
For a TOC value of 10 mg/L the most likely BOD concentration = 4.31 mg/L
Lower 95% BOD = 3.34 mg/L
Upper 95% BOD = 5.29 mg/L

BOD/TOC Ratio:
Arithmetic Mean = 0.44
Geometric Mean = 0.35
Median = 0.37

Generally, higher TOC concentrations indicate that more oxygen will be consumed by an ecosystem, which may result in an oxygen deficient stream system as the population increases among microorganism communities. The average TOC concentration for Big Sugar Creek is 6.6 mg/L under all flow conditions. Samples that had DO impairments had an average TOC concentration of 8.0 mg/L.

Warmer stream temperatures correlate well with observed DO violations in Big Sugar Creek as seen in Figures 13 and 15. Samples with higher temperatures and lower DO concentrations correspond with periods of lower flows, both of which are prevalent in the Summer-Fall Season.

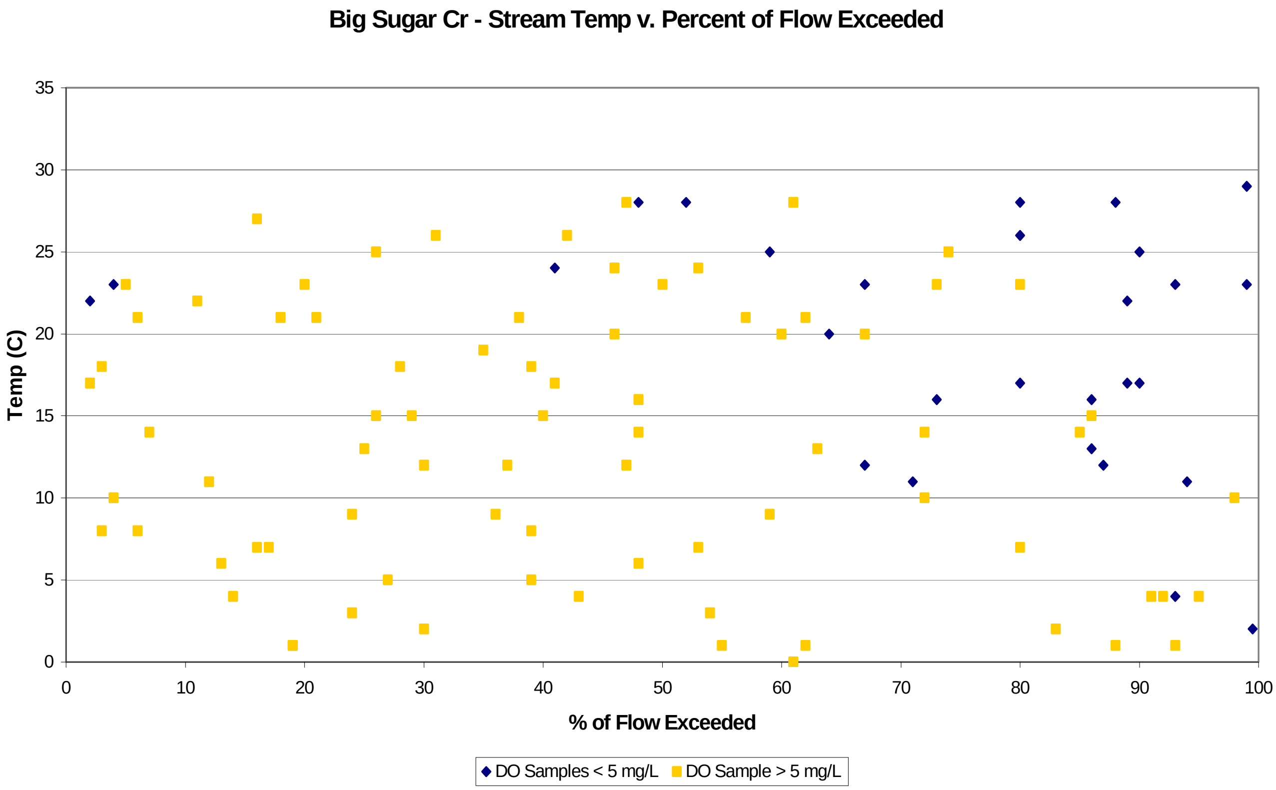
Figure 13. Correlation of DO and temperature observations at Station 558



Background: Deciduous forest comprises 4% of the land cover within the watershed; leaf litter and wastes derived from natural wildlife may add to the nutrient load. Much of the forested land cover buffers the streams within this watershed and may have significant seasonal effects on the DO concentrations within the stream during the fall and early winter months when significant leaf accumulations on the streambed are likely. During a watershed survey conducted by KDHE on October 17, 2006, there was leaf litter in pooled water throughout the streambed along the Big Sugar Creek near the headwaters. Sampling Station 558 was also visited and has a high potential for significant leaf debris accumulations as the trees loose their leaves and it was observed that the water, which was not visibly flowing, was dark in color (Figure 14). The leaf litter may contribute to DO violations in the months of November and December after the leaves have fallen, particularly during prolonged low flow durations.

Figure 14. Photo taken from Sampling Point at Station 558 on October 17, 2006.

Figure 15. Observed Temperature at Station 558 relative to Flow Duration.

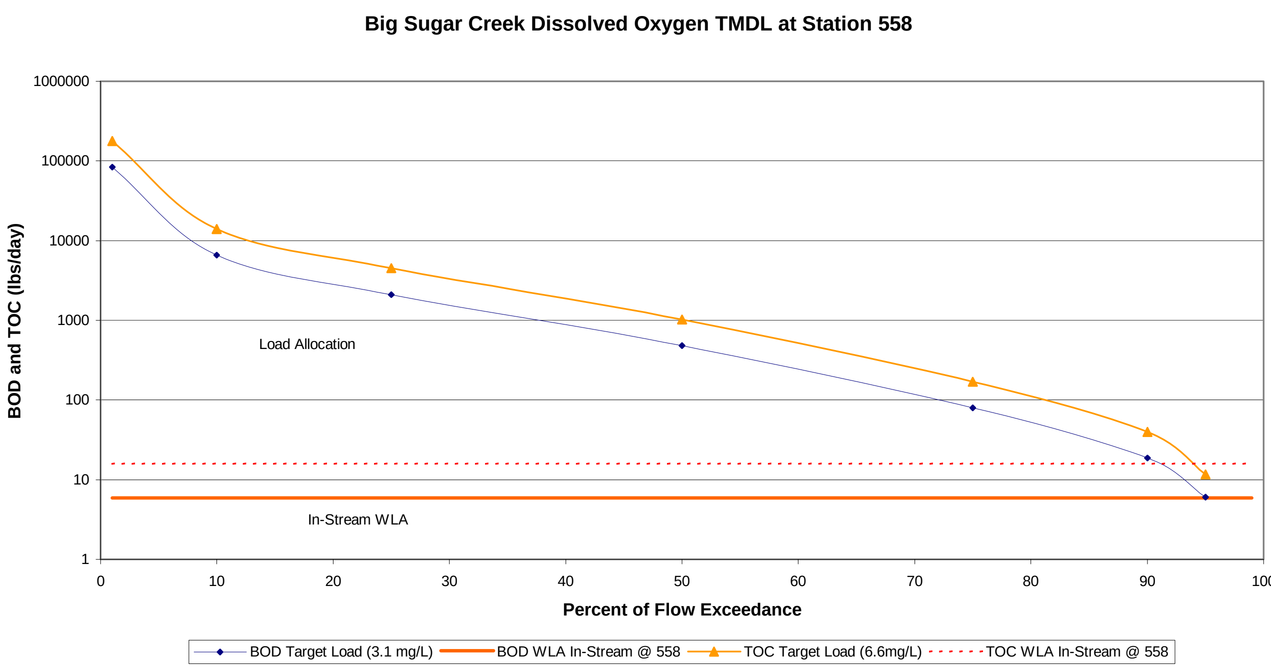


4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

The lack of sufficient dissolved oxygen is caused by a combination of BOD loading, warmer stream temperatures, and insufficient flow to provide re-aeration to the stream. BOD is a measure of the amount of oxygen required to stabilize organic matter in a stream. As such, BOD is a benchmark measure to anticipate DO levels while it measures the total concentrations of DO that will be demanded as organic matter degrades in a stream. KDHE has not sampled site 558 for BOD since 2001. The allocation of wasteloads and loads will be made in terms of BOD. The wasteload and load allocations will also be translated to TOC to accommodate the current sampling procedures.

Point Sources: Above Station 558, current Wasteload Allocations will be set for the City of Parker and Mound City, based on their current permit limits for BOD (30 mg/L) and the design flows of their wastewater treatment facilities. Therefore, the City of Parker will receive a Wasteload Allocation for BOD of 11.5 lbs/day, while Mound City will receive an allocation of 32 lbs/day. This translates to an in-stream WLA of 5.88 lbs/day of BOD or 15.8 lbs/day of TOC (utilizing the median BOD/TOC ratio of 0.37 developed during KDHE's analysis as previously discussed) at Site 558. The City of Parker is not seen as a contributor to the depressed dissolved oxygen seen along Big Sugar Creek because their treatment plant does not discharge directly to a main segment within the watershed and the location is so far upstream that it is unlikely the discharge from the City of Parker is reaching station 558 under lower flow conditions. The analysis through the Streeter-Phelps DO model indicates that the present BOD permit limits for the point sources maintains DO levels above 5 mg/L in the stream when there is no flow upstream of either discharge point during conditions when the stream temperatures are the warmest (See Appendix A). There will be a Wasteload Allocation of zero for the three permitted and one certified CAFOs within the watershed because these facilities should not discharge to Big Sugar Creek, except under extremely atypical high flow events, which are predominately not conducive to incidents of low dissolved oxygen in Big Sugar Creek.

Figure 16. Big Sugar Creek TMDL Load Duration Curve.



Nonpoint Sources: The introduction of organic matter into Big Sugar Creek from runoff events might be the principal source causing the incidents of low dissolved oxygen at flows greater than base flow. The Load Allocation assigns responsibility for maintaining the historical average in-stream BOD levels to 3.1 mg/L and the TOC concentrations to the current average of 6.6 mg/L at Site 558. The associated BOD and TOC Load Allocation will be estimated at site 558 as indicated in Table 6.

Table 6. Big Sugar Cr. TMDL, Daily Load Allocation at Station 558.

Flow Condition	LA - BOD lbs/day	LA – TOC lbs/day
Mean Flow – (246 cfs)	4118	8767
10% (394 cfs)	6596	14042
25% (126 cfs)	2109	4491
50% (28.8 cfs)	482	1026
75% (4.76 cfs)	80	170
90% (1.12 cfs)	19	40

Natural/Seasonal Influences: Seasonal low flow and warmer stream temperatures are significant contributing factors leading to DO violations at site 558, particularly when BOD levels are not excessive. Leaf litter may increase the organic materials, which would increase BOD concentrations, within the stream on an annual basis when the deciduous trees within the riparian areas loose their leaves into the stream. However, the impact of leaf litter on the stream system varies from year to year and will be more profound during years of prolonged drought. Leaf litter accumulating during dryer conditions could contribute significant organic loading to a localized portion of the stream; especially if the flow is minimized to the point that pooling occurs. The stream should naturally rebound from the influx of organic material once the stream flow increases enough to flush the accumulated leaf and nutrient loads.

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty of loading and the dissolved oxygen endpoint for the Big Sugar Creek watershed and is considered implicit in this TMDL. Conservative assumptions have been made with the City of Parker and Mound City by assuming they discharge at permitted BOD concentrations at design flows, along with higher temperatures during low flow conditions. The most conservative assumption is that the flow from both of these facilities reaches the monitoring station under low flow conditions, however during low flow conditions the stream typically pools up and the flow from the City of Parker probably does not reach the sampling point. A conservative assumption for nonpoint sources has been established by setting BOD Load Allocations throughout the year under all flow conditions when nonpoint BOD loadings are related to either runoff during high flow events or low flow seasonal events during the time riparian trees and shrubs lose their leaves. The TOC target load has been conservatively set based on the average TOC concentration within the stream. The average value utilized is almost 25% lower than an appropriate regression based BOD/TOC ratio that translates the BOD concentration utilized for the BOD target load to an applicable TOC concentration.

State Water Plan Implementation Priority: Because low dissolved oxygen levels in Big Sugar Creek are often related to natural seasonal conditions resulting in higher temperatures during times of lower flow, this TMDL will be a Medium priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Lower Marais des Cygnes watershed (HUC 8: 10290102) and is classified as Category I with a priority ranking of 12 (High Priority for restoration work) under the Unified Watershed Assessment.

Priority HUC 11s and Stream Segments: Priority should be directed toward the main segments of Big Sugar Creek (segments 32 and 31) and the main segment of Little Sugar Creek (segment 33), since Mound City discharges directly into Little Sugar Creek. The entire Big Sugar Creek watershed comprises the HUC 11: 10290102070.

5. IMPLEMENTATION

Desired Implementation Activities

1. Renew state and federal permits and inspect permitted facilities for permit compliance.
2. Maintain adequate streamflow by ensuring streamflow is not artificially reduced or impeded, particularly during low flow durations.
3. Maintain conservation tillage and contour farming to minimize cropland erosion.
4. Install grass buffer strips where needed along stream and drainage channels in the watershed.
5. Ensure proper on-site waste system operations in proximity to main-stream segments.
6. Ensure that labeled application rates of chemical fertilizers are being followed and implement runoff control measures.
7. Implement nutrient management plans to manage manure land applications and runoff potential.

Implementation Programs Guidance

NPDES and State Permits- KDHE

a. Maintain permit limits for Mound City and the City of Parker and monitoring requirements and ensure compliance.
b. Livestock permitted facilities will be inspected for integrity of applied pollution prevention technologies.
c. Registered livestock facilities with less than 300 animal units will apply pollution prevention technologies.
d. Manure management plans will be implemented

Nonpoint Source Pollution Technical Assistance – KDHE

a. Support Section 319 demonstration projects for reduction of sediment runoff from agricultural activities as well as nutrient management.
b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.

c. Provide technical assistance on nutrient management for livestock facilities in the watershed and practices geared towards small livestock operations which minimize impacts to stream resources.
d. Guide federal programs such as the Environmental Quality Improvement Program, which are dedicated to priority subbasins through the Unified Watershed Assessment, to priority watershed and stream segments within those subbasins identified by this TMDL.
e. Assess conditions under the Marais des Cygnes WRAPS and evaluate implementation priority after 2012.

Water Resource Cost Share and Nonpoint Source Pollution Control Programs – SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.
b. Apply conservation farming practices and/or erosion control structures, including no-till, terraces and contours, sediment control basins, and constructed wetlands.
c. Re-evaluate nonpoint source pollution control methods.
d. Install livestock waste management systems for manure storage.
e. Implement manure management plans.

Riparian Protection Program – SCC

a. Develop riparian restoration projects.

Buffer Initiative Program – SCC

a. Install grass buffer strips near streams.
b. Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

Extension Outreach and Technical Assistance – Kansas State University

a. Educate agricultural producers on sediment, nutrient, and pasture management.
b. Educate livestock producers on livestock waste management and manure applications and nutrient management planning.
c. Provide technical assistance on livestock waste management systems and nutrient management planning.
d. Provide technical assistance on buffer strip design and minimizing cropland runoff.
e. Encourage annual soil testing to determine capacity of field to hold phosphorus.
f. Continue to educate residents, landowners, and watershed stakeholders about nonpoint source pollution.

Local Environmental Protection Program – KDHE

a. Inspect on-site waste systems within one mile of priority stream segments.

Division of Water Resources – KDA

a. Ensure future water use or management activities in the watershed do not reduce or impede streamflow during low flow conditions.

Timeframe for Implementation: Conditions will be evaluated based on additional monitoring from 2008-2011.

Targeted Participants: The primary participants for implementation will be KDHE and the Mound City WWTF, as well as agricultural and livestock operations immediately adjacent to the streams within the watershed. Conservation district personnel and county extension agents should conduct a detailed assessment of sources adjacent to streams within the watershed over 2008-2009. Implemented activities should be targeted for:

1. Areas of denuded riparian vegetation along the targeted main stem.
2. Facilities without water quality controls
3. Unbuffered cropland adjacent to the stream
4. Sites where drainage runs through or adjacent to livestock areas
5. Sites where livestock have full access to the stream and it is their primary water supply
6. Poor riparian areas
7. Failing on-site waste systems

Milestone for 2012: In accordance with the TMDL development schedule for the State of Kansas, the year 2012 is the next time TMDLs will be evaluated, revised and developed in the Marais des Cygnes Basin. At that point in time, data from site 558 should indicate evidence of improved dissolved oxygen levels at lower flow conditions.

Delivery Agents: The primary delivery agents for program participation will be KDHE and the Kansas State University Extension Service.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollution.

1. K.S.A. 65-164 and 165 empowers the Secretary of KDHE to regulate the discharge of sewage into the waters of the state.

2. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

3. K.S.A. 2002 Supp. 82a-2001 identifies the classes of recreation use and defines impairment for streams.

4. K.A.R. 28-16-69 through –71 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.

5. K.S.A 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

6. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.

7. K.S.A. 82a-901, *et seq*. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

8. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan*, including selected Watershed Restoration and Protection Strategies.

9. The *Kansas Water Plan* and the Marais des Cygnes River Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollution reduction activities in the state through the Kansas Water Plan. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a Medium Priority consideration and should not receive funding at this time.

Effectiveness: Effective controls can be placed on municipal and livestock waste to minimize wastewater and oxygen demanding substances entering Big Sugar Creek. Improvements in reducing oxygen demanding substance loads to streams can also be accomplished through appropriate management and control systems, including buffer strips and riparian restoration projects.

6. MONITORING

KDHE will continue to collect bimonthly samples at Station 558, including DO measurements, in each of the three defined seasons over 2007-2012. Based on that sampling, the priority status of the 303 (d) listing will be evaluated in 2012. Should the impairment status continue, the desired endpoints under this TMDL may be refined and consideration may be given to direct more intensive sampling to be conducted under specified seasonal low flow conditions over the period 2012-2014. The stream will be evaluated for possible delisting in 2016.

7. FEEDBACK

Public Notice: Public meetings to discuss TMDLs in the Marais des Cygnes Basin have been held since 2001. An active Internet Web site was established at www.kdheks.gov/tmdl/ to convey information to the public on the general establishment of TMDLs in the Marais des Cygnes Basin and these specific TMDLs.

Public Hearing: A Public Hearing on these Marais des Cygnes Basin TMDLs was held in Ft. Scott on May 31, 2007.

Basin Advisory Committee: The Marais des Cygnes Basin Advisory Committee met to discuss these TMDLs on June 22, 2006 in Pomona, November 29, 2006 in Williamsburg, December 18, 2006 in Ft. Scott, January 30, 2007 in Ottawa, March 13, 2007 in Ft. Scott and May 17, 2007 in Ottawa.

Milestone Evaluation: In 2012, evaluation will be made as to implementation of management practices to minimize the nonpoint source runoff contributing to this impairment. Subsequent decisions will be made regarding the implementation approach, priority of allotting resources for implementation and the need for additional or follow up implementation in this watershed at the next TMDL cycle for this basin in 2012.

Consideration for 303d Delisting: Big Sugar Creek will be evaluated for delisting under Section 303d, based on the monitoring data over the period 2008-2015. Therefore, the decision for delisting will come about in the preparation of the 2016 303d list. Should modifications be made to the applicable water quality criteria during the implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision would come in 2007, which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2008-2015.

Revised November 20, 2007

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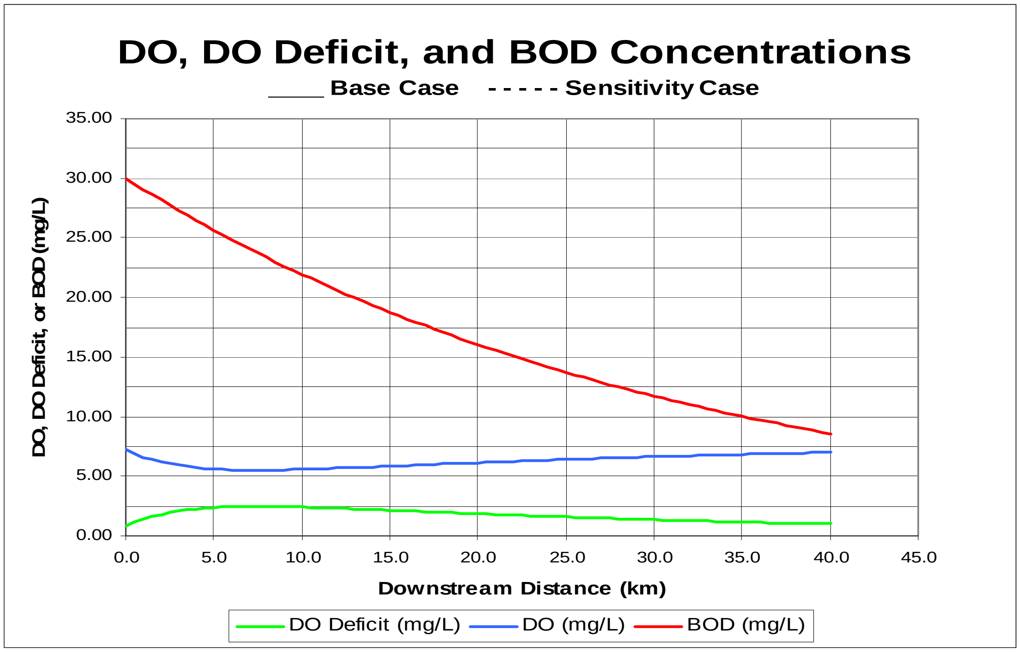
Carney, E.C., May 4, 2000. Kansas Department of Health and Environment Memorandum regarding: Comparison of historic BOD and TOC data in Kansas.

Perry, C.A., D.M. Wolock and J.C. Artman, 2004. Estimates of Low Duration, Mean Flow, and Peak-Discharge Frequency Values for Kansas Stream Locations, USGS Scientific Investigations Report 2004-5033.

Appendix A – Street Phelps Model Results

Figure 17. City of Parker effluent to confluence with Little Sugar.

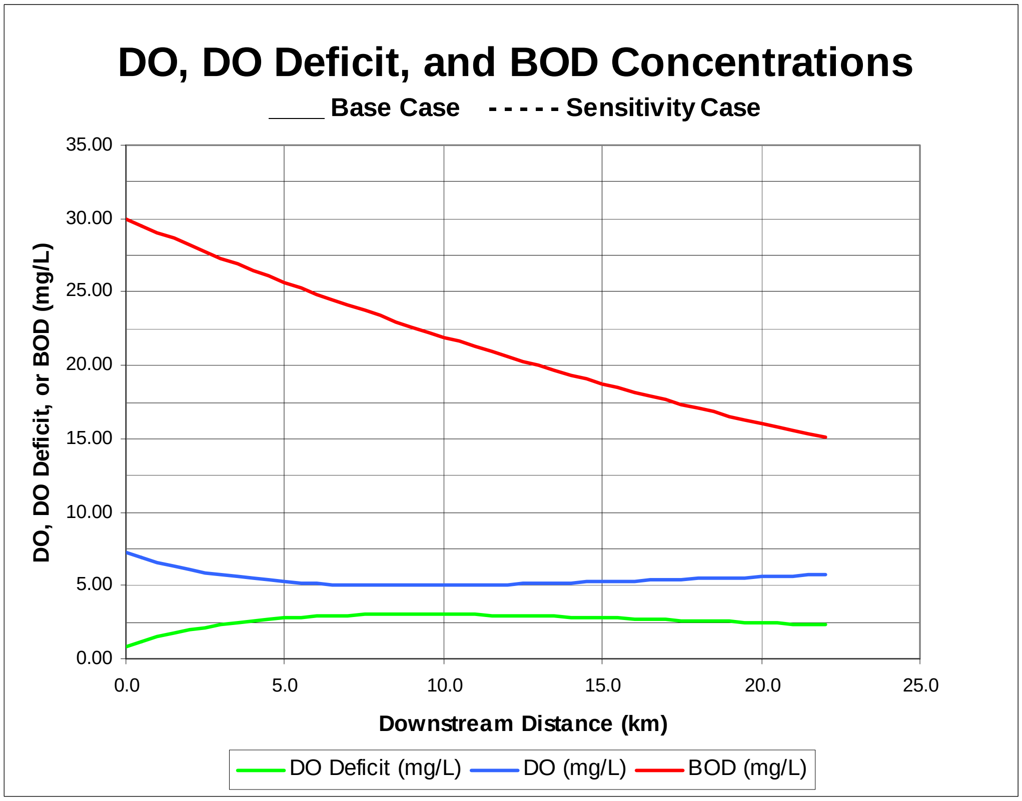


City of Parker to confluence with Little Sugar

Distance (km)	Travel Time (day)	DO Deficit (mg/L)	DO (mg/L)	BOD (mg/L)
0.0	0.00	0.80	7.20	30.00
0.5	0.05	1.12	6.88	29.53
1.0	0.10	1.39	6.61	29.08
1.5	0.16	1.61	6.39	28.62
2.0	0.21	1.80	6.20	28.18
2.5	0.26	1.96	6.04	27.74
3.0	0.31	2.08	5.92	27.31
3.5	0.36	2.18	5.81	26.89
4.0	0.41	2.27	5.73	26.47
4.5	0.47	2.33	5.67	26.06
5.0	0.52	2.38	5.62	25.66
5.5	0.57	2.42	5.58	25.26
6.0	0.62	2.44	5.55	24.87
6.5	0.67	2.46	5.54	24.48
7.0	0.72	2.47	5.53	24.10
7.5	0.78	2.47	5.53	23.73
8.0	0.83	2.47	5.53	23.36
8.5	0.88	2.46	5.54	23.00

9.0	0.93	2.45	5.55	22.64
9.5	0.98	2.43	5.57	22.29
10.0	1.04	2.41	5.59	21.94
10.5	1.09	2.39	5.61	21.60
11.0	1.14	2.37	5.63	21.27
11.5	1.19	2.35	5.65	20.94
12.0	1.24	2.32	5.68	20.61
12.5	1.29	2.29	5.71	20.29
13.0	1.35	2.26	5.73	19.98
13.5	1.40	2.24	5.76	19.67
14.0	1.45	2.21	5.79	19.36
14.5	1.50	2.18	5.82	19.06
15.0	1.55	2.15	5.85	18.77
15.5	1.61	2.12	5.88	18.47
16.0	1.66	2.09	5.91	18.19
16.5	1.71	2.06	5.94	17.91
17.0	1.76	2.03	5.97	17.63
17.5	1.81	2.00	6.00	17.35
18.0	1.86	1.97	6.03	17.08
18.5	1.92	1.94	6.06	16.82
19.0	1.97	1.91	6.09	16.56
19.5	2.02	1.88	6.12	16.30
20.0	2.07	1.86	6.14	16.05
20.5	2.12	1.83	6.17	15.80
21.0	2.17	1.80	6.20	15.55
21.5	2.23	1.77	6.23	15.31
22.0	2.28	1.75	6.25	15.08
22.5	2.33	1.72	6.28	14.84
23.0	2.38	1.69	6.31	14.61
23.5	2.43	1.67	6.33	14.38
24.0	2.49	1.64	6.36	14.16
24.5	2.54	1.62	6.38	13.94
25.0	2.59	1.59	6.41	13.73
25.5	2.64	1.57	6.43	13.51
26.0	2.69	1.54	6.46	13.30
26.5	2.74	1.52	6.48	13.10
27.0	2.80	1.50	6.50	12.89
27.5	2.85	1.47	6.53	12.69
28.0	2.90	1.45	6.55	12.50
28.5	2.95	1.43	6.57	12.30
29.0	3.00	1.40	6.59	12.11
29.5	3.06	1.38	6.62	11.92
30.0	3.11	1.36	6.64	11.74
30.5	3.16	1.34	6.66	11.56
31.0	3.21	1.32	6.68	11.38
31.5	3.26	1.30	6.70	11.20
32.0	3.31	1.28	6.72	11.03
32.5	3.37	1.26	6.74	10.86
33.0	3.42	1.24	6.76	10.69
33.5	3.47	1.22	6.78	10.52
34.0	3.52	1.20	6.80	10.36
34.5	3.57	1.18	6.82	10.20
35.0	3.62	1.16	6.83	10.04
35.5	3.68	1.15	6.85	9.88
36.0	3.73	1.13	6.87	9.73
36.5	3.78	1.11	6.89	9.58

Figure 18. Mound City to confluence with Big Sugar Cr.

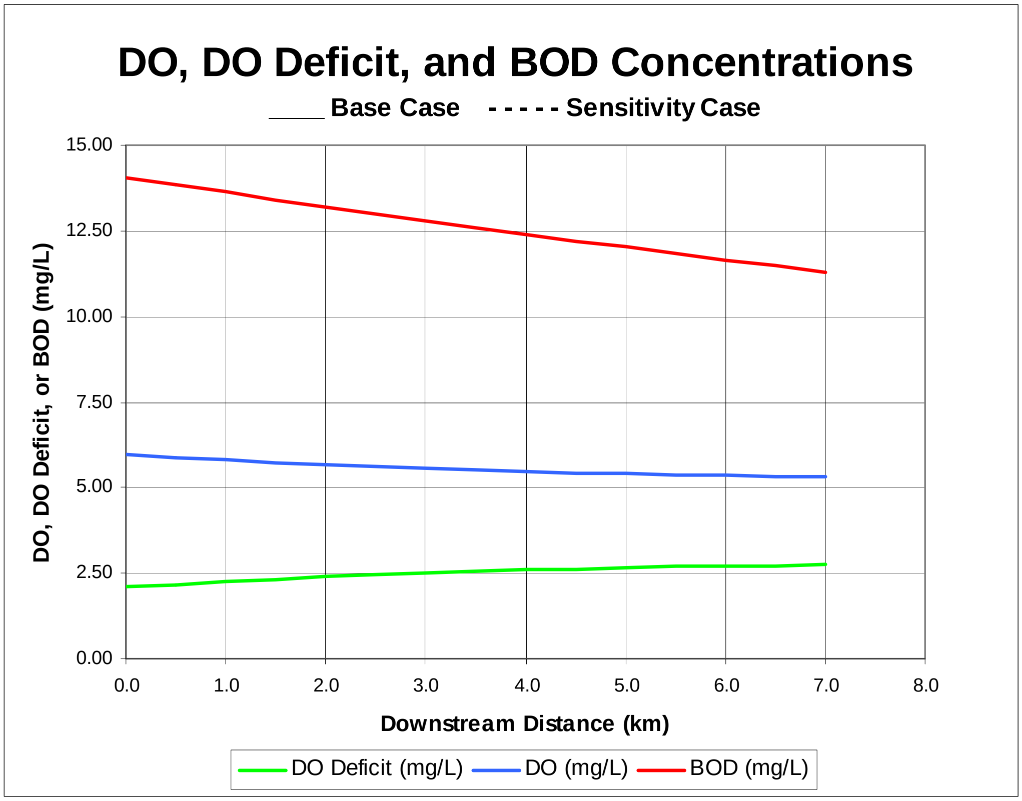


Little Sugar Cr at Mound City to confluence with Big Sugar Creek

Distance (km)	Travel Time (day)	DO Deficit (mg/L)	DO (mg/L)	BOD (mg/L)
0.0	0.00	0.81	7.23	30.00
0.5	0.05	1.16	6.88	29.53
1.0	0.10	1.46	6.57	29.08
1.5	0.16	1.73	6.31	28.62
2.0	0.21	1.96	6.08	28.18
2.5	0.26	2.15	5.88	27.74
3.0	0.31	2.32	5.71	27.31
3.5	0.36	2.47	5.57	26.89
4.0	0.41	2.59	5.45	26.47
4.5	0.47	2.69	5.35	26.06
5.0	0.52	2.78	5.26	25.66
5.5	0.57	2.85	5.19	25.26
6.0	0.62	2.90	5.13	24.87

6.5	0.67	2.95	5.09	24.48
7.0	0.72	2.98	5.06	24.10
7.5	0.78	3.01	5.03	23.73
8.0	0.83	3.02	5.01	23.36
8.5	0.88	3.03	5.01	23.00
9.0	0.93	3.04	5.00	22.64
9.5	0.98	3.03	5.01	22.29
10.0	1.04	3.03	5.01	21.94
10.5	1.09	3.01	5.02	21.60
11.0	1.14	3.00	5.04	21.27
11.5	1.19	2.98	5.06	20.94
12.0	1.24	2.96	5.08	20.61
12.5	1.29	2.94	5.10	20.29
13.0	1.35	2.91	5.13	19.98
13.5	1.40	2.88	5.16	19.67
14.0	1.45	2.85	5.19	19.36
14.5	1.50	2.82	5.22	19.06
15.0	1.55	2.79	5.25	18.77
15.5	1.61	2.76	5.28	18.47
16.0	1.66	2.73	5.31	18.19
16.5	1.71	2.69	5.35	17.91
17.0	1.76	2.66	5.38	17.63
17.5	1.81	2.62	5.42	17.35
18.0	1.86	2.59	5.45	17.08
18.5	1.92	2.55	5.48	16.82
19.0	1.97	2.52	5.52	16.56
19.5	2.02	2.48	5.55	16.30
20.0	2.07	2.45	5.59	16.05
20.5	2.12	2.42	5.62	15.80
21.0	2.17	2.38	5.66	15.55
21.5	2.23	2.35	5.69	15.31
22.0	2.28	2.31	5.73	15.08

Figure 19. From Confluence of Big Sugar Creek and Little Sugar Cr to Sampling Station 558.



Model results starting at confluence of Big Sugar Cr and Little Sugar Cr to sampling station 558.

Distance (km)	Travel Time (day)	DO Deficit (mg/L)	DO (mg/L)	BOD (mg/L)
0.0	0.00	2.08	5.97	14.06
0.5	0.05	2.17	5.88	13.84
1.0	0.10	2.26	5.80	13.63
1.5	0.16	2.33	5.73	13.41
2.0	0.21	2.40	5.66	13.21
2.5	0.26	2.45	5.60	13.00
3.0	0.31	2.51	5.55	12.80
3.5	0.36	2.55	5.50	12.60
4.0	0.41	2.59	5.46	12.41
4.5	0.47	2.63	5.43	12.21
5.0	0.52	2.66	5.39	12.02
5.5	0.57	2.69	5.37	11.84
6.0	0.62	2.71	5.35	11.65

6.5 0.67 2.73 5.33 11.47

Figure 20. Streeter-Phelps DO Sag Model

Streeter-Phelps DO Sag Model - Big Sugar Creek Watershed
Single Reach - Single Load

1 cfs = .0283 m^3/s
0.25 mph =0 .11176 m/s

		Elev (ft)	Dist (km) to Site 558	Min DO	Crit Dist DO
0.0020283	Design Flow (Parker)	1000	41.83	5.53	7.43
0.0056914	Design Flow (Mound City)	850	27.35	5.00	9.00
0.0077197	Comb. Design Flows at Confluence	785	6.44	5.32	6.50

Elevation Correction (DO)

Elevation	**785**	ft
Correctn Factor (DO_{sat})	0.97488	mg/L

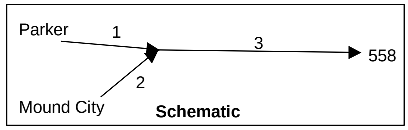
Unless modified by upstream pt. source, upstream BOD set as target for basin
Upstream DO (where appropriate) elevation corrected and set at 90% sat.

Velocity	0.11176		
BOD coef	0.23	Theta	1.056
O2 coef	(see Calc K_r)	Theta	1.024

Distance (km)
Flow (m^3/s)
Concentration (mg/L)
Temp (C)
Vel (m/s)

	Flow	BOD	DO	T	Dist (km)	Slope (ft.mi)	Calc K_r	
1 **Parker**	0.0020283	30	7.2	25	35.40	9.77	2.58	
Upstream	0	0	0	0	-----			
Result at Dist (B Sugar.)	0.002028332	9.88	6.85	25				Elev = 1000 ft
2 **Mound City**	0.0056914	30	7.23	25	20.92	7.60	2.00	
Upstream	0	0	0	0	-----			
Result at Dist (Little Sugar)	0.005691413	15.55	5.66	25				Elev = 850 ft
3 LSugar Cr. (Mound City)	0.0056914	15.55	5.66	25	6.44	3.75	1.03	
Upstream (Parker Result)	0.002028332	9.88	6.85	25	-----			
Result at Dist (Site 558)	0.007719745	11.47	5.33	25				Elev = 785 ft

Kr Values (Foree 1977) using	0.42 (0.63 + 0.4S^1.15)
for q < 0.05 where q = cfs/mi^2 and	S (ft/mile)



Schematic

Appendix B – Summary of paired T-Test and Pearson Correlation Test indicating no significant difference between historic flow data and current flow data.

Paired T-Test for Old Flow – Recent Flow

Old Flow	107	3091.26	7491.12	724.19
Recent Flow	107	3188.29	6866.70	663.83
Difference	107	-97.0285	923.9922	89.3257

95% CI for mean difference: (-274.1254, 80.0684)
T-Test of mean difference = 0 (vs not = 0): T-Value = -1.09 P-Value = 0.280

Pearson Correlation of Old Flow and Recent Flow = 0.995
P-Value = 0.000